Final Report
SwRI Project 15-8957
Research on Orbital Plasma Electro-Dynamics (ROPE)
NASA Contract No. NAS8-36840
Contract Period from 12/13/85 – 9/30/98

Background

This report spans activities covering approximately 13 years. This period includes both the TSS1 and 1R missions. As is well known the TSS1 mission was not successful due to the tether hanging in the reelout mechanism. This resulted in the approval of a reflight mission, TSS1-R. The reel mechanism did work on the reflight however the tether arced, burned through and flew away just as maximum length was being obtained. Thus only a few of the planned objectives were carried out. The good news is that all items delivered under this contract worked as planned. In addition the contract was completed on time and in scope with no overruns. Several publications have resulted even under these non-optimum conditions.

Scope of Work

SwRI was the main hardware and software Co-I for the Research on Plasma Electrodynamics (ROPE) experiment, Dr. N.H. Stone (MSFC) P.I. ROPE consisted of several subunits listed below:

1.) Soft Particle Energy Spectrometer (5 ea.)

2.) Differential Ion Flux Probe

3.) Central Electronics Package

4.) Boom Mounted Electronics

5.) Boom Bias High Voltage Supply

6.) High Voltage Supplies (2 ea.)

All items except 2 were designed and constructed at SwRI. Item 2 was done by MSFC. SwRI also integrated the complete ROPE system. Integration and test were carried out jointly with MSFC. In addition SwRI designed and implemented much of the reduction and analysis software for ROPE. The final task was scientific analysis and publication. This task was greatly limited by the two system failures but useful results and papers were obtained.

For TSS1 SwRI conceived, designed, implemented, tested, and operated the TSS Science Operations Center. This system handled all TSS data and formed the basis for long term archiving. For TSS1-R SwRI supported the transfer of the SOC to a MSFC contractor for TSS1-R.

Success and Problems

Most of the ROPE hardware was a variant of systems flown on previous missions. The only completely new system was the boom bias supply. This was a challenging system in that it had to bias as much as 500v away from the charged tether spacecraft. The main uncertainty was how much current it had to carry. In operation the system worked as planned. Lessons learned on TSS1 were used to improve this system for TSS1-R where it worked flawlessly. Another worry was high voltage arcing in the SPES or HVPS units. In the end no problems were encountered and even inbay operation was

successful during water and waste dumps. Thus all system exceeded their performance requirements.

Systems such as ROPE had never been flown in an environment like that for TSS, i.e. spacecraft bias as high as +500v. Thus we had to model the expected responses and set our sensitivities by these models. Fortunately the models were accurate and all sensors operated in range with only a few brief saturation events.

No significant, threatening hardware problems were encountered during construction, test, and both flights. Thus the hardware on both missions met and exceeded requirements. Unfortunately the system failures limited their scientific success.

The SOC system was a large challenge. No real time system such as this had been attempted for a NASA shuttle science mission. The total, composite bit rate was over 200 kbps with ~1000 separate data quantities. A workstation based system was developed that worked to plan for TSS1. Based on TSS1 experience the system was augmented with more network capability which significantly enhanced performance. In summary the SOC system met and exceeded the requirements for realtime and delayed time support of the two TSS missions. This was accomplished at a fraction of the cost and time of typical systems.

In summary all flight and ground hardware and software deliverable met or exceeded their requirements.

Publications and Presentations

Suprathermal Electrons Observed on the TSS1-R Satellite, J.D. Winningham, N.H. Stone, C.A. Gurgiolo, K.H. Wright, R.A. Frahm, C.A. Bonifazi, *J. Geophys. Res.*, 25, 429-432, 1998.

Observation of Reflected Ions and Plasma Turbulence for Satellite Potentials Greater than the Ion Ram Energy, K.H. Wright, N.H. Stone, J. Sorensen, J.D. Winningham, and C. Gurgiolo, *J. Geophys. Res.*, 24, 417-420, 1998.

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Current-Voltage Characteristics of the Tethered Satellite System: Measurements and Uncertainties Due to Temperature Variations, C.L. Chang, A.T. Drobot, K. Papadopoulos, K.H. Wright, N.H. Stone, C. Gurgiolo, J.D. Winningham, and C. Bonifazi, *Geophy. Res. Lett.*, 25, 713-716, 1998.

Data Creation Using the SCF System, C. Gonzalez, J.D. Winningham, and C.A. Gurgiolo, presented at 1995 IS&T/SPIE Symposium.

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Election Collection by the TSS Satellite, C.L. Chang, A.T. Drobot, P. Satya-Narayana, K. Papadopoulos, J.D. Winningham, C. Gurgiolo, N. Stone, K. Wright, and D. Intriligator, presented at 1996 Spring AGU.

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Ion Outflow from the TSS Satellite Plasma Sheath, K.H. Wright, Jr., N.H. Stone, J. Sorensen, J.D. Winningham, and C. Bonifazi, presented at 1996 Fall AGU.

Temperature Dependent Tether Resistance and its Effects on the IV Characteristics of the TSS System, C.L. Chang, A. Drobot, D. Papadopoulos, K. Wright, N. Stone, C. Gurgiolo, and J.D. Winningham, presented at 1996 Fall AGU.

Energetic Electrons Observed on TSS-1R, Their Dependence on Spacecraft Voltage and Relationship to Tether Current, J.D. Winningham, C.A. Gurgiolo, N.H. Stone, and K. Wright, presented at 1996 Fall AGU.

TSS-1R Satellite Potential Measurements during the Current Flow Events, J.P. Lebreton, G. Vannaroni, F. DeVenuto, J.D. Winningham, C. Gurgiolo, M. Dobrowolny, C. Bonifazi, B. Gilchrist, D. Hardy, and S. Couturier, presented at 1996 Fall AGU.

Near Wake Depletion of Non-magnetized Bodies Immersed in Mesosonic Plasma Flow, K.H. Wright, N.H. Stone, U. Samir, P. Israelevich, J. Sorensen, J.D. Winningham, presented at 1997 Fall AGU.

New Observations on Suprathermal Electrons on the TSS1-R Satellite, J.D. Winningham, presented 1998 Spring AGU.

Unexpected Correlated Signatures of Magnetic Field and High-Energy Ions Observed During the TSS-1R Mission, S. Orsini, M. Marcucci, G. Vannaroni, F. DeVenuto,

F. Mariani, M. Candidi, R. Frahm, D. Intriligator, J.D. Winningham, and N. Stone, presented at 1998 Fall AGU.